24 Greenland shark *Somniosus microcephalus* in the Northeast Atlantic

24.1 Stock distribution

The known North Atlantic distribution of Greenland shark *Somniosus microcephalus*, which has been defined primarily by observations of specimens caught in cold-water commercial fisheries, extends from temperate waters to the Arctic Ocean (MacNeil *et al.*, 2012). It ranges from Georgia (USA) to Greenland, Iceland, Spitzbergen and the Arctic coasts of Russia and Norway to the North Sea and Ireland, with only very occasional individuals recorded further south (Ebert and Stehmann, 2013). Due to their known tolerance for extreme cold water and their ability to inhabit abyssal depths, Greenland sharks may be more widespread. The known distribution is also compromised by taxonomic problems in this genus (MacNeil *et al.*, 2012). The metapopuation structure is unknown.

24.2 The fishery

24.2.1 History of the fishery

Fishing for Greenland shark has been a part of the Scandinavian, Icelandic and Inuit cultures for centuries, extending back to the 13th and 14th century in Norway and Iceland, respectively. Although the meat of Greenland shark may be toxic when fresh (e.g. Anthoni *et al.*, 1991; McAllister, 1968), it is eaten in some countries after curing.

In the early to mid-20th century, Greenland sharks were caught in large quantities as a source of liver oil. At that time, peak annual catches e.g. in Norway are thought to have been in the order of 58 000 individuals (Ebert and Stehmann, 2013; MacNeil *et al.*, 2012). After the invention of synthetic oil in the late 1940s, demand for shark oil diminished, and no intensive fisheries for Greenland sharks have been reported since (Nielsen *et al.*, 2014).

Greenland shark is still targeted in small-scale artisanal fisheries in Iceland and Greenland. Artisanal fisheries target Greenland shark with hook and line, longline or gaffs, but it is also taken in seal nets and cod traps (Ebert and Stehmann, 2013). It is also an occasional bycatch in longline, trawl and gillnet fisheries in the cooler waters of the North Atlantic.

24.2.2 The fishery in 2020

No specific changes in the fishery were apparent in 2020. Apart from Iceland, no countries have reported landings since 2016. Iceland reported landings of 17, 9, 6 and 16 tonnes in 2017, 2018, 2019 and 2020, respectively.

24.2.3 ICES Advice applicable

ICES has not been asked to provide advice on Greenland shark.

24.2.4 Management applicable

In 2016, Regulation (EU) 2016/2336 specified conditions for fishing for deep-sea stocks in the north-east Atlantic and provisions for fishing in international waters of the north-east Atlantic and included the Greenland shark to the list of deep-sea sharks on EC quota regulations for deep-sea fishes. There is a zero TAC for deep-sea sharks in EU vessels fishing in Union and international waters of ICES subareas 5–10 (EC, 2015).

24.3 Catch data

24.3.1 Landings

Limited landings data are available. More comprehensive landings data are only available from Iceland (www.hagstofa.is and Marine Freshwater Research Institute databases). Reported annual landings by Iceland (Table 24.1) from ICES Division 5.a and Subarea 14 have varied from about 2 tonnes (2007) to 87 tonnes (1998). Monthly Icelandic landings of Greenland shark (2005–2020) indicate a peak during the late spring and summer months (Figure 24.1).

24.3.2 Discards

Limited data are available. Greenland shark is a bycatch in trawl fisheries for Greenland halibut *Reinhardtius hippoglossus* and northern shrimp *Pandalus borealis*, as well as in gillnet and longline fisheries (MacNeil *et al.*, 2012; Nielsen *et al.*, 2014).

In the Barents Sea, bycatch of Greenland shark in bottom trawls were related to sea temperature, with more bycatch at lower water temperatures (Rusyaev and Orlov, 2013). Despite limited data on Greenland shark bycatch in the commercial trawl fishery, Rusyaev and Orlov (2013) estimated an annual catch of 140–150 tonnes in the Barents Sea.

In local fishing communities in Greenland, Greenland shark accounts for 50% of the total waste produced by the fishing industry. Estimated annual amounts of waste products of Greenland shark from fishing and hunting in specific counties may be *ca.* 1000 tonnes (Gunnarsdóttir and Jørgensen, 2008).

24.3.3 Quality of catch data

As observers are not mandatory in the fisheries that may have a bycatch of Greenland shark, bycatch levels are uncertain. In some areas there may be confusion with other members of the genus or even basking sharks (MacNeil *et al.*, 2012).

24.3.4 Discard survival

No estimates on discard survival are available for this species. According to on-board observers, some Greenland sharks caught in offshore trawl and longline fisheries are released alive (MacNeil *et al.*, 2012).

Studies with electronic tags have indicated that another deep-water shark, the leafscale gulper shark *Centrophorus squamosus*, one of the species occurring in European seas, can survive after being caught by longline (2–3 h soak time) from waters of 900–1100 m (Rodríguez-Cabello and Sánchez, 2014). Quantified data on the at-vessel mortality (AVM) and post-release mortality (PRM) of deep-water sharks that may be a by-catch in existing deep-water commercial fisheries are currently lacking (Ellis *et al.*, 2016).

24.4 Commercial catch composition

No information available.

24.5 Commercial catch and effort data

No information available.

24.5.1 Recreational CPUE data

There are recreational catch and release fisheries for Greenland sharks in Norway (year-round) and Greenland (in March) (MacNeil *et al.*, 2012), but CPUE data are not available.

24.6 Fishery-independent information

Greenland sharks are caught regularly during gillnet and bottom-trawl surveys around Greenland, such as the Greenland Institute of National Resources Annual bottom trawl survey (Nielsen *et al.*, 2014). Irregular catches are also reported from the annual German Greenland groundfish survey (71 individuals between 1981 and 2019, Figure 24.2). Trawl surveys conducted in the Barents Sea also encounter Greenland shark. Occasional catches are also reported in various Icelandic surveys, but with a total of just 68 observations over the period 1936–2012.

Existing scientific surveys are not appropriate for monitoring the abundance of Greenland sharks in their distribution area because catches are rare.

24.7 Life-history information

24.7.1 Habitat and abundance

Greenland sharks show a marked preference for cold water with most observations from waters of -1.8 to 10°C and the majority of records from waters <5°C (Skomal and Benz, 2004; Stokesbury *et al.*, 2005; Fisk *et al.*, 2012; MacNeil *et al.*, 2012). They occur on continental and insular shelves and upper slopes (Ebert and Stehmann, 2013). Confirmed observations cover a broad depth range from abyssal depths of at least 1560 m (Fisk *et al.*, 2012) to shallow water (Yano *et al.*, 2007; MacNeil *et al.*, 2012). Devine *et al*. (2018) found that off the northern Canadian coast, shark densities peaking at intermediate temperatures sampled, and at depths between 450–800 m. Though primarily considered a demersal species, it may be caught both at the surface and in the pelagic zone (e.g. Stokesbury *et al.*, 2005; MacNeil *et al.*, 2012). They often associate with fjord habitats (MacNeil *et al.*, 2012).

Using baited remote underwater video cameras, Devine *et al*. (2018) calculated Greenland shark abundance and biomass in Arctic Canada. Density estimates varied from 0.4 to 15.5 individuals per km^2 (biomass: 93.3–1210.6 kg per km^2) among regions; being highest in warmer (>0 °C), deeper areas and lowest in shallow, sub-zero temperature regions.

24.7.2 Spawning, parturition and nursery grounds

The only captures of Greenland shark with near-term embryos were near fjords in the Faroe Islands. Based on observations on two presumed neonatal specimens captured by mid-water trawl off Jan Mayen Island, Kondyurin and Myagkov (1983) suggested that parturition may occur in the Norwegian Sea in July–August. Specimens of presumed neonatal size have also been reported from Canadian, Norwegian and Greenland fjords (Bjerkan and Koefoed, 1957).

24.7.3 Age and growth

Greenland shark is the second largest shark in the ICES area and the largest fish inhabiting Arctic seas (Ebert and Stehmann, 2013). Bigelow and Schroeder (1948) reported a maximum size of 640 cm L_T and weight of 1023 kg. Females may attain a larger size than males. The growth rate of Greenland sharks is unknown, but observations from tagging experiments indicate growth rates of 0.5–1 cm y^{-1} (Hansen, 1963). Conventional vertebral ageing methods are not applicable for Greenland shark (MacNeil *et al.*, 2012). However, a recent study using radiocarbon analysis from eye lenses suggests that Greenland sharks live to be several hundred years-old (Nielsen *et al.*, 2016).

24.7.4 Reproductive biology

The Greenland shark is an aplacental viviparous species (Carrier *et al.*, 2004; Ebert and Stehmann, 2013). The exact size at birth as well as the gestation period remain unknown, but size at birth is thought to be *ca.* 40–100 cm L_T (MacNeil *et al.*, 2012). Size-at-maturity is difficult to determine. The onset of maturity in male Greenland sharks probably occurs at *ca.* 260 cm L_T but is variable, and males may reach maturity at *ca.* 300 cm L_T (Yano *et al.*, 2007). Females from Icelandic waters mature at 355–480 cm L_T (MacNeil *et al.*, 2012). Based on changes in ovary weight, Yano *et al.* (2007) suggested that females matured at >400 cm L_T. Nielsen *et al.* (2016) suggested the age at sexual maturity to be at least 156 ± 22 years. Fecundity is uncertain, but has been suggested to be approximately ten (Bjerkan and Koefoed, 1957; Ebert and Stehmann, 2013; Carter and Soma 2020); however, Nielsen *et al.* (2020) suggested a much larger fecundity, estimating up to 200–324 pups per pregnancy (depending on maternal size) with a body length-at-birth of 35–45 cm.

24.7.5 Movements and migrations

Studies using conventional and electronic (satellite and acoustic) tags have informed on the movements and migrations of Greenland sharks. Recent studies deploying archival pop-off tags (PATs) have shown that sharks display a broad vertical distribution, but no obvious diel movements were noted (Campana *et al.*, 2015; Fisk *et al.*, 2012). Tagged sharks move into deeper water when they mature, and it is possible that they migrate offshore to mate and/or give birth (Campana *et al.*, 2015). A recent study revealed a previously unknown directed migration from Canadian Arctic to NW-Greenland (Hussey *et al.* 2018). Previous studies have also examined the behaviour of Greenland sharks in the Northwest Atlantic (Skomal and Benz, 2004; Stokesbury *et al.*, 2005). All such studies have found examples of localized movements and site fidelity, as well as some larger scale movements.

24.7.6 Diet and role in ecosystem

Greenland sharks feed on a wide variety of invertebrates, fish and marine mammals, indicating they are generalist predators on both benthic and pelagic organisms (MacNeil *et al.*, 2012; Nielsen *et al.*, 2014), and they are important predators in Arctic food webs (Leclerc *et al.*, 2012). They are also important scavengers, including of whales (Leclerc *et al.*, 2011). Recent studies showed an ontogenetic dietary shift with small sharks (<200 cm) mainly feeding on lower trophic level prey such a squid, while larger sharks feed on seals as well as epibenthic and benthic fishes. Additionally, it was indicated that Greenland sharks are capable of active predation on fast swimming mammals and large fishes (Nielsen *et al.*, 2019).

24.8 Exploratory assessment models

No exploratory stock assessments have been undertaken.

24.9 Stock assessment

No stock assessment has been undertaken.

24.10 Quality of the assessment

No stock assessment has been undertaken.

24.11 Reference points

No reference points have been proposed for this stock.

24.12 Conservation considerations

On the basis of possible population declines and limiting life-history characteristics, the Greenland shark is listed as Vulnerable in the IUCN Red List (Kulka *et al.*, 2020). It is listed vulnerable in the Swedish Red List of endangered species (Svensson *et al.*, 2010).

24.13 Management considerations

Stock status and many other aspects of the biology of Greenland sharks are unknown. Given the large body size of this species and perceived low population productivity, further studies to better understand population dynamics and sources of mortality are required.

Ruud (1968) reported a longer-term decline in Greenland shark in the Oslofjord, but it is unclear as to how such local depletions towards the south of the distribution range relate to wider population trends.

24.14 References

Anthoni, U., Christophersen, C., Gram, L., Nielsen, N.H. and Nielsen, P. 1991. Poisonings from flesh of the Greenland shark *Somniosus microcephalus* may be due to trimethylamine. *Toxicon*, 29: 1205–1212.

Bigelow, H.B. and Schroeder, W.C. 1948. Sharks. In Tee-Van, J., Breder, C.M., Hildebrand, S.F., Parr, A.E. and Schroeder, W.C. (Eds.) Fishes of the Western North Atlantic, Part 1. Yale, CT: Yale University, Sears Foundation for Marine Research: 59–546.

Bjerkan, P. and Koefoed, E. 1957. Notes on the Greenland Shark *Acanthorhinus carcharias* (Gunn). Report on Norwegian Fishery and Marine Investigations, 11: 1–12.

Campana, S.E.,Fisk, A.T. and Klimley, A. 2015. Movements of Arctic and northwest Atlantic Greenland sharks (*Somniosus microcephalus*) monitored with archival satellite pop-up tags suggest long-range migrations. *Deep Sea Research Part II.* 115:109-115.

Carrier, J.C., Pratt, H.L. Jr. and Castro, J.I. 2004. Reproductive biology of elasmobranchs. In Carrier J.C., Musick, J.A. and Heithaus, M.R. (Eds.) Biology of Sharks and their Relatives, Boca Raton, FL, CRC Press: 269–286.

Carter, A.M. and Soma, H., 2020. Viviparity in the longest-living vertebrate, the Greenland shark (*Somniosus microcephalus*). Placenta, 97, pp.26-28.

EC. 2015. Council Regulation (EU) No 1367/2014 of 15 December 2014 fixing for 2015 and 2016 the fishing opportunities for Union fishing vessels for certain deep-sea fish stocks. Official Journal of the European Union L 366; 1–14.

Devine, B. M., Wheeland, L. J. and Fisher, J. A. 2018. First estimates of Greenland shark (Somniosus microcephalus) local abundances in Arctic waters. Scientific reports, 8(1), p.974.

Ebert, D.A. and Stehmann, M.F. 2013. Sharks, batoids, and chimaeras of the North Atlantic, Food and Agriculture Organization of the United Nations: 537 pp.

Ellis, J. R., McCully Phillips, S. R. and Poisson, F. 2017. A review of capture and post-release mortality of elasmobranchs. Journal of fish biology, 90(3), pp.653-722.Fisk, A.T., Lydersen, C. and Kovacs, K.M. 2012. Archival pop-off tag tracking of Greenland sharks *Somniosus microcephalus* in the High Arctic waters of Svalbard, Norway. *Marine Ecology Progress Series*, 468: 255–265.

Gunnarsdóttir, R. and Jørgensen, M.W. 2008. Utilization possibilities of waste products from fishing and hunting to biogas and bio-oil production in Uummannaq County. In Sustainable Energy Supply in the Arctic - sun, wind, water, etc.: ARTEK Event. Arctic Technology Centre, Department of Civil Engineering, Copenhagen: 52–58.

Hansen, P.M. 1963. Tagging Experiments with the Greenland shark (*Somniosus microcephalus* (Block and Schneider)) in Subarea 1. International Commission for the Northwest Atlantic Fisheries. Special Publication, 4: 172–175.

Hussey, N. E., Orr, J., Fisk, A. T., Hedges, K. J., Ferguson, S. H. and Barkley, A. N. 2018. Mark report satellite tags (mrPATs) to detail large-scale horizontal movements of deep water species: First results for the Greenland shark (Somniosus microcephalus). Deep Sea Research Part I: Oceanographic Research Papers, 134, pp.32-40.

Kondyurin, V.V. and Myagkov, N.A. 1983. Catches of newborn Greenland shark, *Somniosus microcephalus* (Bloch and Schneider) (Dalatiidae). *Journal of Ichthyology* 23: 140–141.

Kulka, D.W., Cotton, C.F., Anderson, B., Derrick, D., Herman, K. & Dulvy, N.K. 2020. *Somniosus microcephalus*. The IUCN Red List of Threatened Species 2020: e.T60213A124452872. https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T60213A124452872.en. Downloaded on 06 July 2021.

Leclerc, L.-M., Lydersen, C., Haug, T., Bachmann, L., Fisk, A. and Kovacs, K. 2012. A missing piece in the Arctic food web puzzle? Stomach contents of Greenland sharks sampled in Svalbard, Norway. *Polar Biology*, 35: 1197–1208.

Leclerc, L.-M., Lydersen, C., Haug, T., Glover, K. A., Fisk, A. T. and Kovacs, K. M. 2011. Greenland sharks (*Somniosus microcephalus*) scavenge offal from minke (*Balaenoptera acutorostrata*) whaling operations in Svalbard (Norway). *Polar Research*, 30: 4 pp.

MacNeil, M.A., McMeans, B.C., Hussey, N. E., Vecsei, P., Svavarsson, J., Kovacs, K.M., Lydersen, C., *et al*. 2012. Biology of the Greenland shark *Somniosus microcephalus. Journal of Fish Biology*, 80: 991–1018.

McAllister, D.E. 1968. Poisonous and venomous fishes of Canada. National Museum of Canada Natural History Papers, 42: 2–3.

Nielsen, J., Hedeholm, R.B., Lynghammar, A., McClusky, L.M., Berland, B., Steffensen, J.F. and Christiansen, J.S., 2020. Assessing the reproductive biology of the Greenland shark (*Somniosus microcephalus*). PloS one, 15(10), p.e0238986.

Nielsen, J., Christiansen, J.S., Grønkjær, P., Bushnell, P., Steffensen, J.F., Kiilerich, H.O., Præbel, K. and Hedeholm, R. 2019. Greenland shark (*Somniosus microcephalus*) Stomach Contents and Stable Isotope Values Reveal an Ontgenetic Dietary Shift. *Frontiers in Marine Science*, 6: 125. doi: 10.3389/fmars.2019.00125

Nielsen, J, Hedeholm, R.B., Bushnell, P.G., Christiansen, J.S., Olsen, J.,Bronk, C.B., Brill, R.W. *et al*. 2016. Eye lens radiocarbon reveals centuries of longevity in the Greenland shark (*Somniosus microcephalus*). *Science*, 253:702-704

Nielsen, J., Hedeholm, R.B., Simon, and M.J., Steffensen, 2014. Distribution and feeding ecology of the Greenland shark (*Somniosus microcephalus*) in Greenland waters. *Polar Biology*, 37: 37–46.

Rodríguez-Cabello, C. and Sánchez, F. 2014. Is *Centrophorus squamosus* a highly migratory deep-water shark? Deep Sea Research, Part I 92, 1–10

Rusyaev, S. and Orlov, A. 2013. Bycatches of the Greenland shark *Somniosus microcephalus* (Squaliformes, Chondrichthyes) in the Barents Sea and adjacent waters under bottom trawling data. *Journal of Ichthyology*, 53: 111–115.

Ruud, J. T. 1968. Changes since the turn of the century in the fish fauna and the fisheries of the Oslofjord. *Helgoländer Wissenschaftliche Meeresuntersuchungen*, 17: 510–517.

Skomal, G.B. and Benz, G.W. 2004. Ultrasonic tracking of Greenland sharks, *Somniosus microcephalus*, under Arctic ice. *Marine Biology*, 145: 489–498.

Stokesbury, M.J.W., Harvey-Clark, C., Gallant, J., Block, B.A. and Myers, R.A. 2005. Movement and environmental preferences of Greenland sharks (*Somniosus microcephalus*) electronically tagged in the St. Lawrence Estuary, Canada. *Marine Biology*, 148: 159–165.

Svensson, M., Degerman, E., Florin, A.-B., Hagberg, J., Kullander, S.O., Nathanson, J.E. and Stenberg, C. 2010. Fiskar–Fish. Pisces. In Gärdenfors, U. (Ed.) Rödlistade arter i Sverige 2010 –The 2010 Red List of Swedish Species. ArtDatabanken, SLU, Uppsala: 323–332.

Yano, K., Stevens, J.D. and Compagno, L.J.V. 2007. Distribution, reproduction and feeding of the Greenland shark *Somniosus* (*Somniosus*) *microcephalus*, with notes on two other sleeper sharks, *Somniosus* (*Somniosus*) *pacificus* and *Somniosus* (*Somniosus*) *antarcticus*. Journal of Fish Biology, 70: 374–390.

Electronic references

http://www.hagstofa.is Accessed 06th July 2021.

Table 24.1. Greenland shark *Somniosus microcephalus* in the Northeast Atlantic. Preliminary estimates of landings (t) for the period 1992–2020). Data were updated with landings from ICES historic nominal landings database (ICES, 2016) and national landings data provided to the WG (June 2021).

Year	Iceland	Greenland	Portugal	Sweden	Total
1992	68				68
1993	41				41
1994	42				42
1995	43				43
1996	61				61
1997	73				73
1998	87				87
1999	51				51
2000	45				45
2001	57				57
2002	56				56
2003	55				55
2004	58				58
2005	50		0.3		50
2006	28		0.5		29
2007	2	17	0.7		20
2008	42		0.6		43
2009	26			0.4	26
2010	43				43
2011	18				18
2012	19				19
2013	6				6
2014	60	8			68
2015	28	17			45
2016	26				26
2017	17				18
2018	9				8
2019	6				6
2020	16				

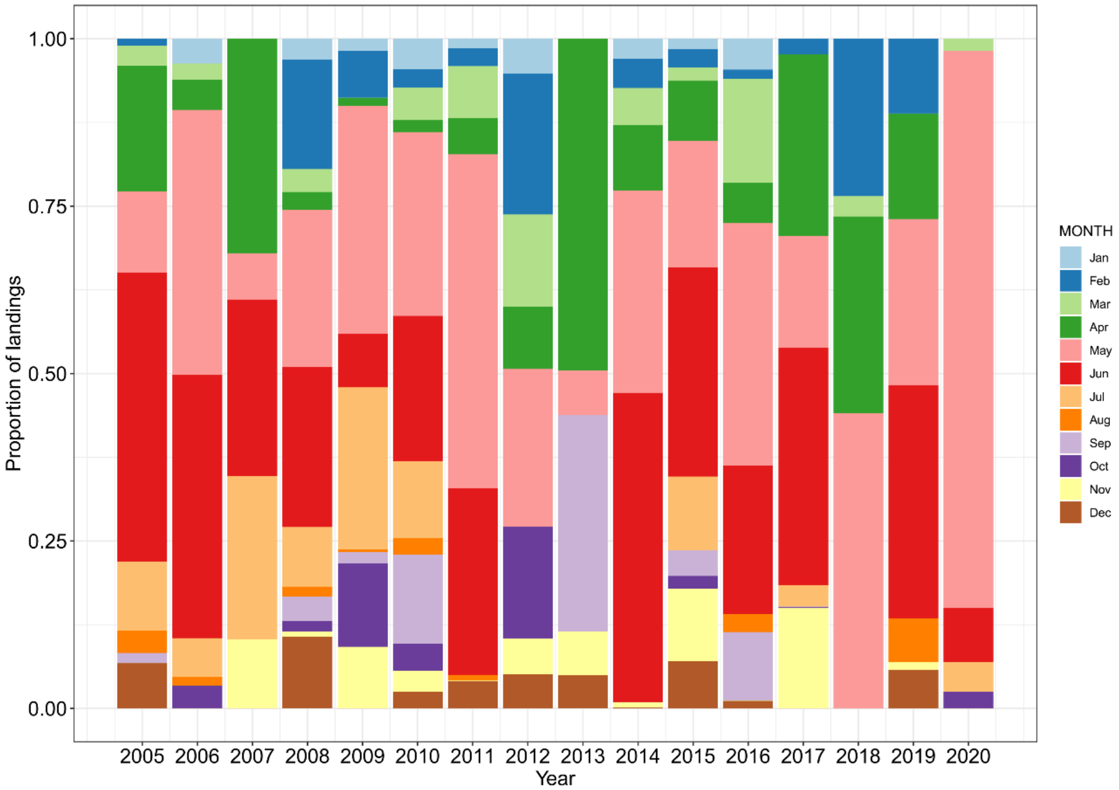

Figure 24.1. Greenland shark (*Somniosus microcephalus*) in the Northeast Atlantic. Monthly Icelandic landings of Greenland shark 2009–2020. Data from www.hagstofa.is

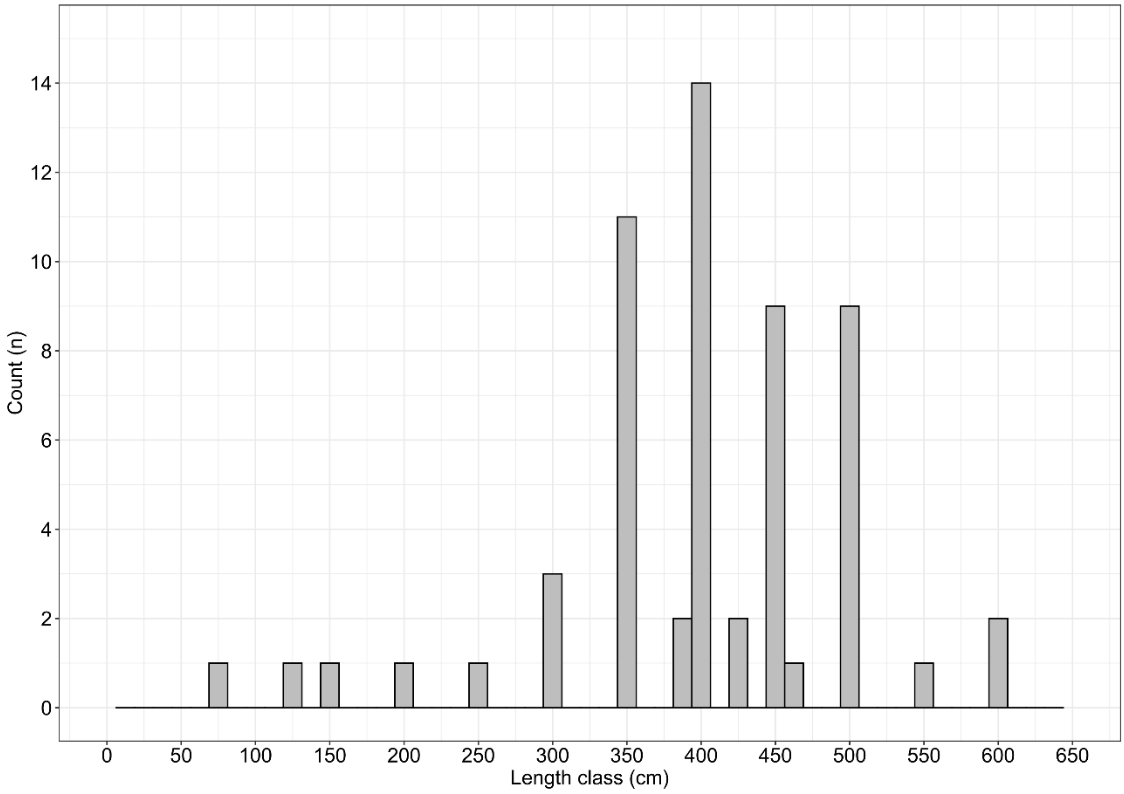

Figure 24.2. Greenland shark (*Somniosus microcephalus*) in the Northeast Atlantic. Length distribution of Greenland shark captured during the annual German Greenland Groundfish Survey (1981–2020; n = 72; length measurements available for n = 60 specimens).